sand, and peas selected of good round form, and other small round seeds, such as clover-seed and poppy-seed. Granules such as these showed very clearly numerous phenomena, not only of the flow of the water, but also of the transmission of material-like detritus forward along the bottom in straight parts, and very obliquely across the bottom in the bend; and gave imitations on a small scale, easy for observation, of the processes of accumulation of detritus along the inner banks of the bends of rivers, and presented also interesting suggestions and considerations as to some of the details or secondary actions involved in the processes *.

VII. "An Attempt to form Double Salts of Nitrate of Silver and other Nitrates." By W. J. Russell, Ph.D., F.R.S., and Nevil Story Maskelyne, F.R.S. Received June 21, 1877.

(Abstract.)

When a solution containing silver and potassium nitrates, in equivalent proportions, is evaporated, the potassium nitrate separates out, uncombined with silver nitrate. If, however, the ratio of silver nitrate to potassium nitrate be increased beyond a certain limit (which has been determined), then a true double salt having the composition $AgNO_3KNO_3$ crystallizes out. The same salt can also be formed from a solution that would *not* yield it under ordinary circumstances, by either adding nitric acid or by increasing the temperature of the solution, both these alterations tending in the same direction, viz. to decrease the amount of silver nitrate as compared to that of potassium nitrate which can exist in solution.

Further it is shown, with regard to these two salts, that if an intimate mixture of them be treated with an amount of water insufficient to dissolve the whole of either constituent, still the composition of the solution found will vary with the composition of the mixture used. This arises from the two salts uniting in solution to form the double salt, and ultimately the amount of double salt that can remain in solution depending on the excess of silver nitrate present, which, from its greater solubility, can displace the double salt from solution. The residue in this case, from its crystalline form, can be identified as double salts.

With sodium nitrate a corresponding double salt does not form. In this case, on evaporating the solution it is the silver nitrate, not the

* The experiments here described were shown in the Mathematical and Physical Section of the British Association at the meeting held at Glasgow, in September 1876, and further in the temporary collection prepared in the Helvingrove Museum at Glasgow, for that meeting of the Association. As they were arranged expressly for testing and illustrating the theoretical views contained in a paper previously submitted to the Royal Society, the present brief account of them is offered here to the Society as a sequel to that previous paper.

sodium nitrate, which is the first to separate out, notwithstanding its being by far the more soluble salt of the two. The solution obtained by treatment of the two salts with insufficient water does not vary in composition, as is the case with the potassium salt, and this is known to be a strong confirmation of the statement of the non-existence of a double salt of silver and sodium.

With ammonium nitrate a double salt is formed corresponding to the potassium salt. In this case, owing to the similar degree of solubility of both constituents, it forms on the evaporation of a solution containing the salts in the proportion of single equivalents. On treatment of the salts with insufficient water for solution the same thing happens as with the potassium salts.

With lithium nitrate no double salt could be formed; but on the evaporation of a solution having the two salts in equivalent proportions, it is the very soluble silver nitrate which is the first to separate out. Again, the composition of the solution obtained by treating different amounts of the dry salts with insufficient water to dissolve them gives in all cases a liquid of constant composition.

With lead nitrate no double salt was formed. On evaporation, in this case, it is the least soluble, the lead nitrate, which is the first to separate out.

When two salts are together in solution, in some cases the more soluble, in others the less soluble, will be the first to separate out on evaporation; this action appears to depend on the affinity of the salt for water—its hygroscopic character, not its solubility.

The distinctive character of the double salt is confirmed by its crystalline form, which is similar in the two cases of the potassium- and the ammonium-silver salt.

The system to which these crystals belong is the oblique; the elements of the crystal being

$$a : b : c = 1{\cdot}405 : 1 : 1{\cdot}646$$

$$\eta = 82^\circ\ 22'$$

$$101 \,.\, 100 = 37^\circ\ 14',\ 101 \,.\, 001 = 45^\circ\ 8',\ 111 \,.\, 010 = 45^\circ\ 7'.$$

Other important angles are:—

$$100 \,.\, \bar{1}01 = 136^\circ\ 20', \quad 100 \,.\, 110 = 54^\circ\ 19',$$
$$110 \,.\, \bar{1}10 = 71^\circ\ 20', \quad 010 \,.\, 011 = 31^\circ\ 29\tfrac{1}{2}'.$$

The faces of the forms $\bar{2}11$ and $\bar{1}22$ appear to be hemimorphously developed.

Averages occur parallel to the faces of the forms $\{\bar{1}01\}$ $\{110\}$ $\{101\}$.

Optical character negative; the optic axes lie in a plane perpendicular to the plane of symmetry, their divergence for red light being about 4° 25′, for blue light 13° 11′. The (horizontal) dispersion of the first mean lines in the plane of symmetry throws the mean line for red rays

about 13′ nearer the normal of the face (1 0 0) than that of the blue, the mean direction of the first mean line being about 35° on the normal of 1 0 0, and 8° 40′ on that of $\bar{1}$ 0 1.

Crystals of potassium nitrate, containing less silver nitrate than the double salt, gave angles according somewhat closely with those of ordinary nitre; but the crystals did not give very good reflections.

The results obtained by Rose with sodium nitrate containing silver nitrate were confirmed so far as the crystals permitted of measurement.

Crystals of strontium nitrate containing silver nitrate gave excellent measurements, according with those of a cubo-octahedron.

VIII. "On certain Definite Integrals." By W. H. L. Russell, F.R.S. Received June 21, 1877.

The following paper is a continuation of two papers recently communicated to the Royal Society, and inserted in the 'Proceedings.'

$$(40.)\quad \int_0^\pi d\theta \log_\epsilon\left(\epsilon^{2x\cos\theta}+2\epsilon^{x\cos\theta}\cos(x\sin\theta)+1\right)=2\pi\log_\epsilon 2.$$

$$(41.)\quad \int_0^{\frac{\pi}{2}} d\theta\, \epsilon^{2\cos^4\theta}\cos(\sin 2\theta\cos^2\theta+\sin\theta\cos\theta)=\frac{\pi}{2}\sqrt[4]{\epsilon^3}.$$

$$(42.)\quad \int_0^\pi d\theta\, \epsilon^{\cos 2\theta+\cos\theta}\cos(\sin 2\theta+\sin\theta)=\pi.$$

$$(43.)\quad \int_0^\pi d\theta\, \epsilon^{\frac{1-x^2}{1-2x\cos\theta+x^2}}\cos\frac{2x\sin\theta}{1-2x\cos\theta+x^2}=\pi\epsilon.$$

$$(44.)\quad \int_0^\pi d\theta\,.\,\epsilon^{\frac{1-x\cos\theta}{1-2x\cos\theta+x^2}}\cos\frac{x\sin\theta}{1-2x\cos\theta+x^2}=\pi\epsilon.$$

$$(45.)\quad \int_0^\pi \theta d\theta\,.\frac{\sin\theta\,(4+\cos^2\theta)}{(3+\sin^2\theta)^2}=\frac{\pi}{3}.$$

$$(46.)\quad \int_0^\pi \frac{\theta\sin^3\theta d\theta}{1-x^2\cos^2\theta}=\frac{\pi(x^2-1)}{2x^3}\log_\epsilon\frac{1+x}{1-x}+\frac{\pi}{x^2}.$$

$$(47.)\quad \int_0^\pi \frac{\theta\sin^3\theta\, d\theta}{1+x^2\cos^2\theta}=\frac{\pi(x^2+1)}{x^3}\tan^{-1}x-\frac{\pi}{x^2}.$$